Drawing Amendments

Applicant is providing a replacement drawing for Figure 1 that expressly discloses the optional step of dividing a converged FIR filter into a first set of coefficients and a second set of coefficients and converting the second set of coefficients into an IIR filter.

This drawing addition does not represent new matter. The specification expressly discloses this optional step on page 17, lines 18-23:

> As discussed above, to avoid degrading system performance through inaccuracies in detecting the start and/or end of the response, it is preferred in echo cancellation applications to truncate the converged FIR filter, take a first set of taps, K, from the truncated FIR filter, referred to as h_{fir}, take the last N-K taps of the truncated FIR filter, referred to as h_{iir}, and convert h_{iir} to an IIR model, where K is preferably at or around 10. The truncated FIR filter, h_{fir}, together with the IIR filter are then used, in combination, to track the system response and filter data.

Applicant respectfully requests the Examiner to accept the amended drawing.

Remarks

In his office action dated July 16, 2004, Examiner stated the following objections and rejections:

1. Figures 2 and 4 should be designated as Prior Art because only those which are old are illustrated.

2. Figures 2, 5, 6, and 7 are objected to because the figures show "a summing point wherein signal 225 must show '+' sign, and signal 215 "-" sign.

3. The Figures fail to show every feature of claims 8, 10, 13, and 14-16. The feature of dividing coefficients into a first and second set and then converting the second set is not shown (claims 8, 13, and 14-16) and the encoder/decoder feature is not shown (claim 10).

4. The specification does not include certain symbols on page 16, lines 16 and 20.

5. Claim 1 is objected because it recites converting a first set of FIR coefficients into an IIR filter whereas, according to the Examiner, the specification requires converting a second set of FIR taps, thereby making the claims and specification inconsistent. Additionally, the term "said FIR filter" is indefinite because it fails to specifically refer to one of two sections of the filter.

6. Claim 4 is objected because it recites an infinite impulse response (IIR) filter when, according to the Examiner, it should recite a finite impulse response (IIR) filter. Additionally, the term "said FIR filter" is indefinite because it fails to specifically refer to one of two sections of the filter.

7. Claims 8, 13, and 14-16 are not supported by the specification because, according to the Examiner, the feature of "dividing coefficients into a first and second set" is not disclosed.

8. Claim 14 is objected to because it recites "second/coefficients" when it should read "second coefficients".

9. Claim 11 is objected to because it fails to specifically refer to one of two sections of the filter.

10. Claims 1-4, 6-7, and 12 are rejected under 35 USC 102 as

being anticipated by Gysel et al [US 5,633,863].

11. Claim 5 is rejected under 35 USC 103(a) being unpatentable over Gysel in view of Dowling [6,507,732] and Kaelin et al [IEEE Int. Symp. On Circuits and Systems].

12. Claim 9 is rejected under 35 USC 103(a) being unpatentable over Johnson [US 6,141,406] in view of Williamson et al [IEEE Trans. On Signal Processing, Vol. 44, No. 6, June 1996, pp. 1418-1427].

13. Claim 10 is rejected under 35 USC 103(a) being unpatentable over Li [US 6,549,587] in view of Azriel [US 6,724,736] and further in view of Williamson et al.

14. Claim 11 is rejected under 35 USC 103(a) being unpatentable over Sugiyama [US 20020101981] in view of Williamson et al.

15. Claims 17 and 18 are rejected under 35 USC 103(a) being unpatentable over Strait [US 6,266,367] in view of Williamson et al.

Applicant has addressed each of the objections and rejections below:

1. <u>Figures 2 and 4 should be designated as Prior Art because only those which are old are illustrated.</u>

Applicant respectfully disagrees. The application expressly states that the figures are intended to represent systems that use the novel filters of the present invention.

Specifically, while filters are generally known, the adaptive filter of Figure 2 is disclosed as using the novel methods and systems of the present invention. See Page 5, Line 25 ["Fig. 2 is a block diagram of one embodiment of the novel adaptive filter system.]. On page 6 of the specification, applicant uses Figure 2 to provide the reader with an understanding of the context of its invention and goes to describe how the filter 210 of figure 2 is novel. If forced to label Figure 2 as prior art, it would create the erroneous impression, when read with the specification, that applicant believes its novel adaptive filter is part of the prior art,

thereby undermining the objective and purpose of this application.

Similarly, Figure 4 is intended to represent a network that uses the novel methods and systems of the present invention. See page 15, lines 8-11 ["The novel adaptive filter method and system can be effectively deployed in a telecommunications system in the form of novel echo cancellation methods and systems to effectuate high quality communications, particularly as between users of a public switched telephone network (PSTN) and users of a packet-based network (e.g., the Internet)."] If forced to label Figure 4 as prior art, it would create the erroneous impression, when read with the specification, that applicant believes its novel adaptive filter is part of the prior art, thereby undermining the objective and purpose of this application. Applicant requests the Examiner withdraw these objections.

2. <u>Figures 2, 5, 6, and 7 are objected to because the figures show "a summing point wherein signal 225 must show '+' sign, and signal 215 "-" sign.</u>

Applicant respectfully disagrees. Applicant does not understand how Examiner reached the conclusion that the invention is limited to each signal having a specific positive or negative value. One of ordinary skill in the art would appreciate that signal 215 is removed from signal 225, regardless of which signal has a positive or negative value. The inclusion of such detail in the drawings is not required by the MPEP and does not represent an erroneous technical representation of the invention. Applicant requests the Examiner withdraw this objection.

3. <u>The Figures fail to show every feature of claims 8, 10, 13, and 14-16. The feature of dividing coefficients into a first and second set and then converting the second set is not shown (claims 8, 13, and 14-16) and the encoder/decoder feature is not shown (claim 10).</u>

Applicant has submitted a replacement drawing for Figure 1

that expressly discloses the optional step of dividing a converged FIR filter into a first set of coefficients and a second set of coefficients and converting the second set of coefficients into an IIR filter. This drawing addition does not represent new matter. The specification expressly discloses this optional step on page 17, lines 18-23. Applicant respectfully requests the Examiner to accept the amended drawing.

The encoder/decoder limitation of claim 10 has been deleted, thereby rendering the Examiner's objection to claim 10 moot.

4. <u>The specification does not include certain symbols on page 16, lines 16 and 20.</u>

Pursuant to 37 C.F.R. 1.125, applicant is providing a clean version and marked up version of substitute specification pages 16-18. Applicant is submitting substitute specification pages because, upon review, it has been determined that symbols, which were in the electronic version of the application, failed to properly print. While the substance of the information and equations represented by the symbols clearly communicates the nature and scope of the invention, applicant believes that, for purposes of clarity, substitute specification pages with the symbols should be provided. With the substitute specification pages, applicant believes it has satisfactorily met the Examiner's objection.

5. <u>Claim 1 is objected because it recites converting a first set of FIR coefficients into an IIR filter whereas, according to the Examiner, the specification requires converting a second set of FIR taps, thereby making the claims and specification inconsistent. Additionally, the term "said FIR filter" is indefinite because it fails to specifically refer to one of two sections of the filter.</u>

Applicant authored claim 1 using the conventional patent practice of referring to differing coefficients as being "first" or "second". Examiner has literally mapped the term "first" and

"second" to the varied usages in the patent, rather than appreciate that "first" simply refers to one set of coefficients and "second" refers to a different set of coefficients. Applicant believes such a mapping is unwarranted and is contrary to standard patent practice.

However, for purposes of clarity, applicant has clarified what the "first" and "second" coefficients refer to. Specifically, claim 1 was amended to remove the term "first" and clarify that, at least in one embodiment, the term "second" coefficients refers to "FIR" coefficients. The amendments should therefore make clear that the claim is not inconsistent with the specification and is not indefinite.

6. <u>Claim 4 is objected because it recites an infinite impulse response (IIR) filter when, according to the Examiner, it should recite a finite impulse response (IIR) filter. Additionally, the term "said FIR filter" is indefinite because it fails to specifically refer to one of two sections of the filter.</u>

Applicant has amended claim 4 to clarify its scope. Claim 4 patents a method of filtering a signal by, among other steps, deriving an infinite impulse response (IIR) filter using a filter having a predetermined number of coefficients, obtaining convergence of the filter, and converting the filter into the IIR filter. The claim is properly directed toward an IIR filter and does not have terms that could potentially sustain an indefiniteness rejection. Applicant therefore requests Examiner to withdraw his rejection.

7. <u>Claims 8, 13, and 14-16 are not supported by the specification because, according to the Examiner, the feature of "dividing coefficients into a first and second set" is not disclosed.</u>

Applicant respectfully disagrees. The feature of dividing coefficients into a first and second set is expressly disclosed

by the applicant. Specifically, the application expressly discloses the optional step of dividing a converged FIR filter into a first set of coefficients and a second set of coefficients and converting the second set of coefficients into an IIR filter. The specification expressly discloses this optional step on page 17, lines 18-23:

> As discussed above, to avoid degrading system performance through inaccuracies in detecting the start and/or end of the response, it is preferred in echo cancellation applications to truncate the converged FIR filter, take a first set of taps, K, from the truncated FIR filter, referred to as h_{fir}, take the last N-K taps of the truncated FIR filter, referred to as h_{iir}, and convert h_{iir} to an IIR model, where K is preferably at or around 10. The truncated FIR filter, h_{fir}, together with the IIR filter are then used, in combination, to track the system response and filter data.

Applicant respectfully requests the Examiner to withdraw this objection.

8. <u>Claim 14 is objected to because it recites "second/coefficients" when it should read "second coefficients".</u>

Applicant has amended the claim such that the "/" has been removed.

9. <u>Claim 11 is objected to because it fails to specifically refer to one of two sections of the filter.</u>

Applicant authored claim 11 using the conventional patent practice of referring to differing coefficients as being "first" or "second". For purposes of clarity, however, applicant has clarified what the "first" and "second" coefficients refer to. Specifically, claim 11 was amended to remove any potential ambiguity as what the terms "first" and "second" refer to. The amendments should therefore make clear that the claim is not

indefinite.

10. Claims 1-4, 6-7, and 12 are rejected under 35 USC 102 as being anticipated by Gysel et al [US 5,633,863].

Applicant respectfully disagrees with the Examiner's interpretation of U.S. Patent No. 5,633,863 (Gysel). Gysel discloses the use of a FIR filter together with an IIR filter. It *does not* disclose the conversion of an FIR filter into an IIR filter. Figure 10 does not disclose the conversion of a FIR filter section. Rather, the patent merely discloses the use of an IIR filter along with an FIR filter. See Col.7:67-Col.8:5 ("The circuit expenditure of such FIR filters is however rather substantial, so that the utilization of an IIR (Infinite Impulse Response) filter in combination with an FIR filter is proposed"); see also Col.13:65-Col.14:41 (does not disclose the convergence of an FIR filter and conversion of that filter to create an IIR filter). Because Gysel clearly does not disclose the convergence of an FIR filter and use of that converged filter to create an IIR filter, it cannot act as an anticipatory reference to claims 1-4, 6-7 and 12. Applicant respectfully requests the Examiner to withdraw this rejection.

11. Claim 5 is rejected under 35 USC 103(a) being unpatentable over Gysel in view of Dowling [6,507,732] and Kaelin et al [IEEE Int. Symp. On Circuits and Systems].

As stated above, Gysel discloses the use of a FIR filter together with an IIR filter and *does not* disclose the conversion of an FIR filter into an IIR filter. Dowling and Kaelin also do not disclose the conversion of an FIR filter into an IIR filter. Gysel can therefore not be used with Dowling and Kaelin to render claim 5 obvious. Applicant respectfully requests the Examiner to withdraw his rejection.

12. Claim 9 is rejected under 35 USC 103(a) being unpatentable

over Johnson [US 6,141,406] in view of Williamson et al [IEEE Trans. On Signal Processing, Vol. 44, No. 6, June 1996, pp. 1418-1427].

Applicant respectfully disagrees with the Examiner's rejection. Johnson teaches the use of either an FIR filter or an IIR filter:

> The invention has been described in an event detection implementation using an adaptive FIR filter as effected in a Normalized LMS algorithm. This implementation is preferred embodiment, because it works well with speech. As previously noted, it is also possible to use other techniques for identifying and monitoring an echo characteristic that changes with the addition of a secondary telephone destination to the communication.
>
> For example, it is possible to use an adaptive IIR filter. Although an adaptive IIR filter processes incoming signals differently from an adaptive FIR filter, the output is the same. Thus, it would be possible to implement the invention with an adaptive IIR filter using the sum of the squares of the coefficients to identify and monitor the echo characteristic. See Col.10:20-33.

It does not teach a method and system for using an FIR filter to create an IIR filter. In fact, it teaches away from the concept by stating the FIR filter is a preferred embodiment. Moreover, the reference equates the performance of an IIR filter with an FIR filter. Conversely, the purpose of the present invention is to create an improved filtering process and device that combines the benefits of an FIR and an IIR filter.

Williamson discloses an entirely new filter, not an IIR filter derived in the manner disclosed in the specification. Stated differently, Williamson does not begin with an FIR filter and then derive an IIR filter. Rather, the reference begins with a completely different model that Williamson actively compares and contrasts with an FIR filter. See Table 1. In fact, Williamson teaches away from using the methods and systems of the present invention by creating an entirely new form of filter.

No one of ordinary skill in the art would be motivated to combine the two references. Johnson discloses an FIR filter is preferred. Based on that, one of ordinary skill in the art would not seek out Williamson. If one began with Williamson, one would simply use the disclosed model and not seek any other variation or derivation thereof. No combination of references yield the present invention because none of the references disclose the use of an FIR filter to create an IIR filter by converging and converting the FIR filter.

13. Claim 10 is rejected under 35 USC 103(a) being unpatentable over Li [US 6,549,587] in view of Azriel [US 6,724,736] and further in view of Williamson et al.

Applicant has amended claim 10 to include that IIR coefficients are determined by deriving a finite impulse response filter (FIR) having a predetermined number of FIR coefficients, obtaining convergence of FIR filter, and converting the FIR filter to derive the IIR coefficients. Because none of the cited references disclose this inventive element and because the Williamson reference teaches away from disclosures that use an FIR filter, Applicant respectfully requests the Examiner to withdraw this rejection.

14. Claim 11 is rejected under 35 USC 103(a) being unpatentable over Sugiyama [US 20020101981] in view of Williamson et al.

Applicant has amended claim 11 to clarify that the IIR coefficients are determined by deriving a filter having a predetermined number of coefficients, obtaining convergence of the coefficients, and converting the filter into an infinite impulse response (IIR) filter to yield the IIR coefficients. Because none of the cited references disclose this concept and because the Williamson reference teaches away from disclosures that use an FIR filter, Applicant respectfully requests the Examiner to withdraw this rejection.

15. <u>Claims 17 and 18 are rejected under 35 USC 103(a) being unpatentable over Strait [US 6,266,367] in view of Williamson et al.</u>

Applicant has amended claim 17 to clarify that the IIR coefficients are initially determined by deriving an FIR filter having a predetermined number of FIR coefficients, obtaining convergence of the FIR coefficients, and converting the converged FIR coefficients into the IIR coefficients. Original claim 18 includes the generation of IIR coefficients by deriving a finite impulse response (FIR) filter, obtaining convergence of the FIR filter, and converting the filter into the IIR filter. Because none of the cited references disclose this concept and because the Williamson reference teaches away from disclosures that use an FIR filter, Applicant respectfully requests the Examiner to withdraw this rejection.

Applicant believes that it has satisfactorily addressed the bases underlying the Examiner's objections and rejections. Applicant therefore submits the present application is in form for allowance.

Respectfully submitted,

Hazim Ansari
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SUBSTITUTE SPECIFICATION MARKED UP VERSION

a new signal s 540, referred to herein as the echo response 540. The echo response 540 is illustrated here as a signal s 540 corresponding to the following equation:

$$s=h*x$$

where h is the impulse response of the echo characteristics.

Also being communicated through the transmit line 530 is a near-end signal v 545, communicated from a near-end source 550. The input signal v 545 combines with the echo response s 540 to generate a combined signal y 555. Therefore, the signal sent from the near-end source 550 to the far-end receiver 580, absent echo cancellation, is the signal y 555, which is the sum of the near-end signal v 545 and the echo response s 540.

To reduce and/or eliminate the echo response component s 540 from the signal y 555, the a typical system uses an echo canceller 560 having a filter 565 that is capable of applying an impulse response $\underline{\hat{h}}$, which is an estimate of the actual impulse echo response h experienced by the far-end signal x 510 as it engages the cross-coupling path 525. As such, a further signal $\underline{\hat{s}}$ 570 representing an estimate of echo response s 540 is generated by the echo canceller 560 in accordance with the following equation:

$$\underline{\hat{s}} = \underline{\hat{h}} * x$$

The echo canceller 560 subtracts the echo estimate signal $\underline{\hat{s}}$ 570 from the signal y 555 to generate a signal e 575 that is returned to the far-end receiver 580. The signal e 575 thus corresponds to the following equation:

$$e = s+v-\underline{\hat{s}} \approx v$$

The signal returned to the far end receiver 580 is therefore dominated by the signal v of the near-end source 550. To the extent the impulse response $\underline{\hat{h}}$ more closely correlates to the actual echo impulse response h, then $\underline{\hat{s}}$ 570 more closely approximates s 540, resulting in the minimization of the magnitude of the echo signal component s 540 on the signal e.

An adaptive filter 565 is used to generate the echo signal component $\underline{\hat{s}}$ 570. In its simplest form, the adaptive filter 565 generates an echo estimate, i.e. $\underline{\hat{s}}$ 570, by obtaining individual samples of the far-end signal x 510 on a receive path 513, convolving the samples with an impulse response model of the system, i.e. $\underline{\hat{h}}$, and then subtracting, at the appropriate time, the resulting echo estimate, $\underline{\hat{s}}$ 570, from the received signal y 555 on the transmit channel

530. The conventional adaptive filter is a FIR filter using a LMS method for achieving tap convergence.

The novel adaptive filter method and system presented herein can be used to improve the calculation of the echo impulse response $\hat{\underline{h}}$ by, among other things, reducing the computational complexity and memory requirements of the tap calculation conducted within the adaptive filter. Shown in Figure 6, an embodiment of the novel filter 665 of the present invention is used to generate the echo signal component $\hat{\underline{s}}$ 670. After having achieved convergence on a FIR filter and converted the filter to an IIR filter, in accordance with the previously described methodology, the adaptive filter 665 generates an echo estimate, i.e. $\hat{\underline{s}}$ 670, by obtaining individual samples of the far-end signal x 610 on a receive path 613, convolving the samples with the calculated taps, and then subtracting, at the appropriate time, the resulting echo estimate, $\hat{\underline{s}}$ 670, from the received signal y 655 on the transmit channel 630. On going adaptation of the filter occurs by the adjustment of the zeroes of the IIR filter, represented by the arrow 690 extending through element 680 (where $N_{iir}(z)$ denotes the numerator portion of the IIR filter), and not by updating the denominator 675. To match the delay incurred due to conversion of the FIR filter into an IIR filter, a delay where D-1 is a specific value of delay is applied. The signal $\hat{\underline{s}}$ 670 is produced as a function of the transfer function denoted by z^{-D} 685.

As discussed above, to avoid degrading system performance through inaccuracies in detecting the start and/or end of the response, it is preferred in echo cancellation applications to truncate the converged FIR filter, take a first set of taps, K, from the truncated FIR filter, referred to as h_{fir}, take the last N-K taps of the truncated FIR filter, referred to as h_{iir}, and convert h_{iir} to an IIR model, where K is preferably at or around 10. The truncated FIR filter, h_{fir}, together with the IIR filter are then used, in combination, to track the system response and filter data.

Referring now to Figure 7, a second embodiment of the novel filter 765 of the present invention is used to generate the echo signal component $\hat{\underline{s}}$ 770. After having achieved convergence on a FIR filter, dividing the filter taps into an initial K tap and a subsequent N-K coefficients, and converting a portion of the FIR filter to an IIR filter corresponding to the N-K taps, in accordance with the previously described methodology, the adaptive filter 765 generates an echo estimate, i.e. $\hat{\underline{s}}$ 770, by utilizing both the truncated FIR filter 740, comprising $H_{fir}(z)$ 748,

and the IIR filter 745. On going adaptation of the IIR filter 745 occurs by the adjustment of the zeroes of the IIR filter, represented by the arrow 790 extending through element 780 (where $N_{iir}(z)$ denotes the numerator portion of the IIR filter), and not by updating the denominator 785. To match the delay incurred due to conversion of the FIR filter into an IIR filter, a delay where D1-1 is a specific value of delay is applied. The signal $\hat{s}$ 770 is produced as a function of the transfer functions denoted by z^{-D1} 743 and z^{-D2} 747.

Operationally, the novel echo cancellation application has achieved superior performance results in the form of computational savings and decreased filter length. An FIR filter of length N=512 was chosen, converged, and truncated according to the description provided above. The FIR filter was converted to an IIR filter using a pole-zero filter model of p=50 and q=50. To evaluate the ability of the echo cancellation system to adapt to changes over time, two actual hybrid responses, shown as 805, 830 in Figure 8 and as 905, 930 in Figure9, were generated in a PSTN due to an impedance mismatch of a four-wire to two-wire converter and recorded at two different times with an interval of 30 minutes. The two impulse responses 805/905, 830/930 demonstrate that, over time, changes do occur in an impulse response requiring an echo cancellation system, and more specifically, an adaptive filter, to adjust over time. Although on the order of 10^{-3} 940, the differences are sufficient to cause a converged system to generate, over time, a measured error that is unacceptable.

Without an adaptive filter, as shown in Figures 10 and 11, when the impulse response is switched close to 175,000 samples, the error 1050, 1150 increases significantly and to unacceptable levels. The error is measured in amplitude in Figure 10 and in decibels in Figure 11. Conversely, when the echo cancellation system employs one embodiment of the novel adaptive filter system claimed herein, the error 1250, 1350 shows an increase due to a shift in the impulse response but, unlike with a no-adaptive filter case, is at or below acceptable levels. If the filter order were increased, the error level would be further decreased, although memory requirements and computational resource needs would increase.

The present adaptive filter method and system can be employed in numerous applications employing adaptive processes in conjunction with convolutional coding. Accordingly, another embodiment of the present invention includes a novel method and system for channel equalization. Equalizers are a class of communication system devices used to compensate for distortion experienced in communication channels. Fixed equalizers have the average electrical